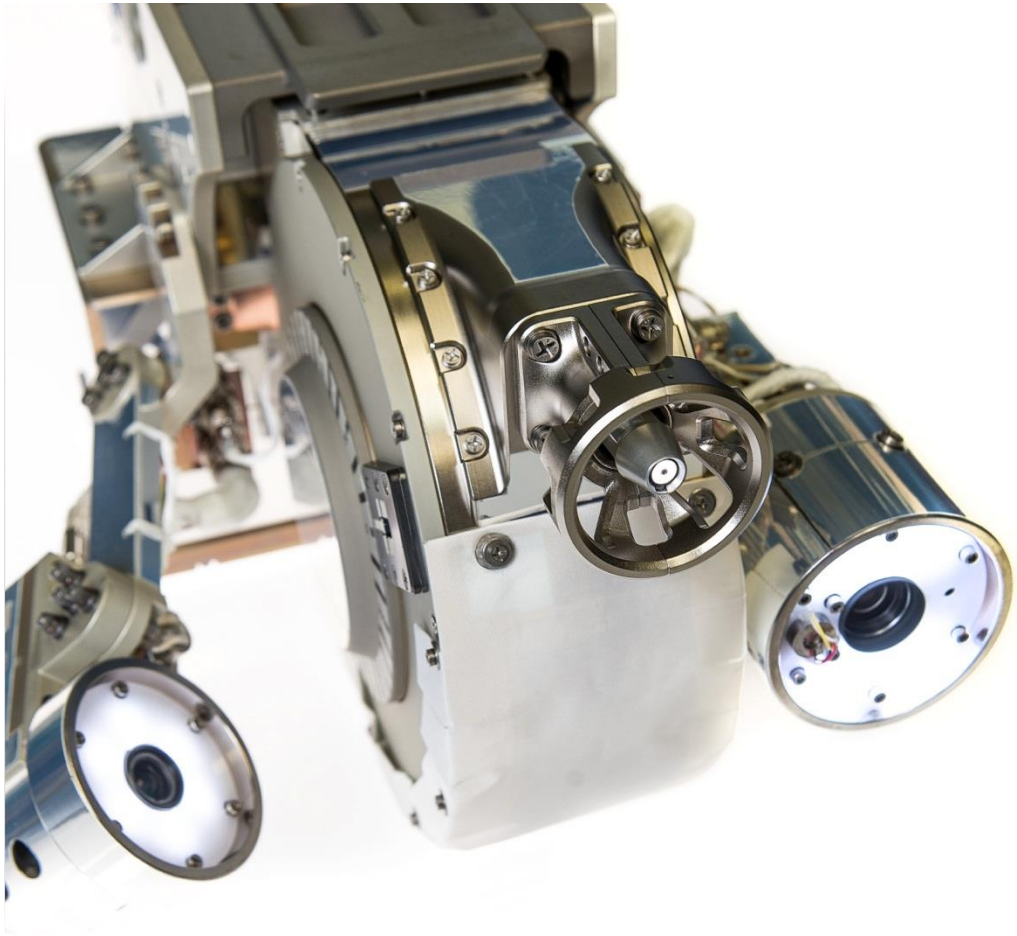
# Satellite Servicing Mission – Inspection Needs



**Presented to the**
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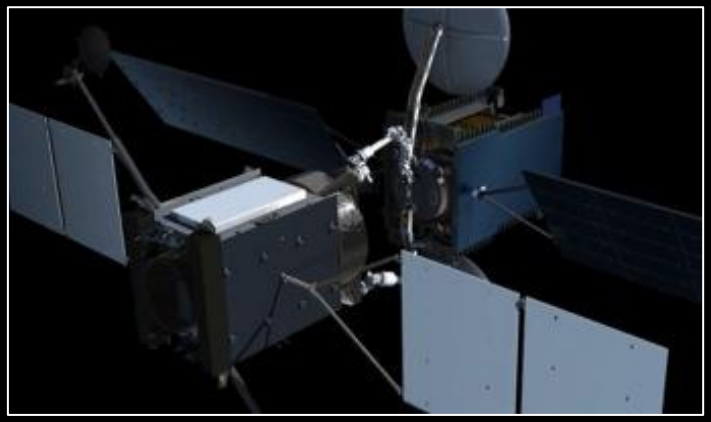
# Satellite Servicing Capabilities

## Servicing provides capabilities for **flexible, resilient architectures.**



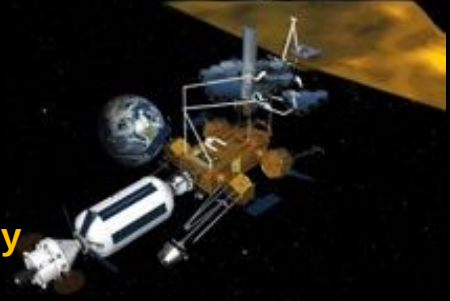
**Anomaly Recovery**
**Instrument Upgrade**
**Life Extension**

**In-Orbit Construction**
**Cryogen Replenishment & Fueling**

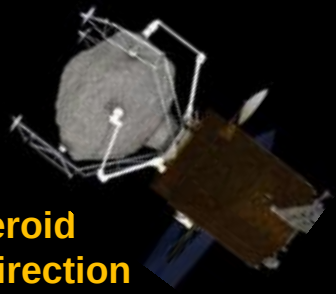
Government and Commercial Fleet Management

Human Exploration

Observatory Upgrade



On-orbit Assembly



Asteroid Redirection

Planetary Defense

Propellant Depot

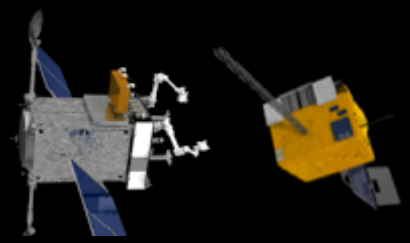
Orbital Debris

**Servicing Capabilities**

## Servicing Missions Enable Robust Architectures

# Technologies That Support the Five Servicing R's

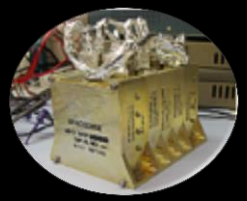
**Remote Survey | Relocation | Refueling | Repair | Replacement**



Autonomous rendezvous & docking sensors & algorithms

Dexterous robotics

High-speed, fault-tolerant computing

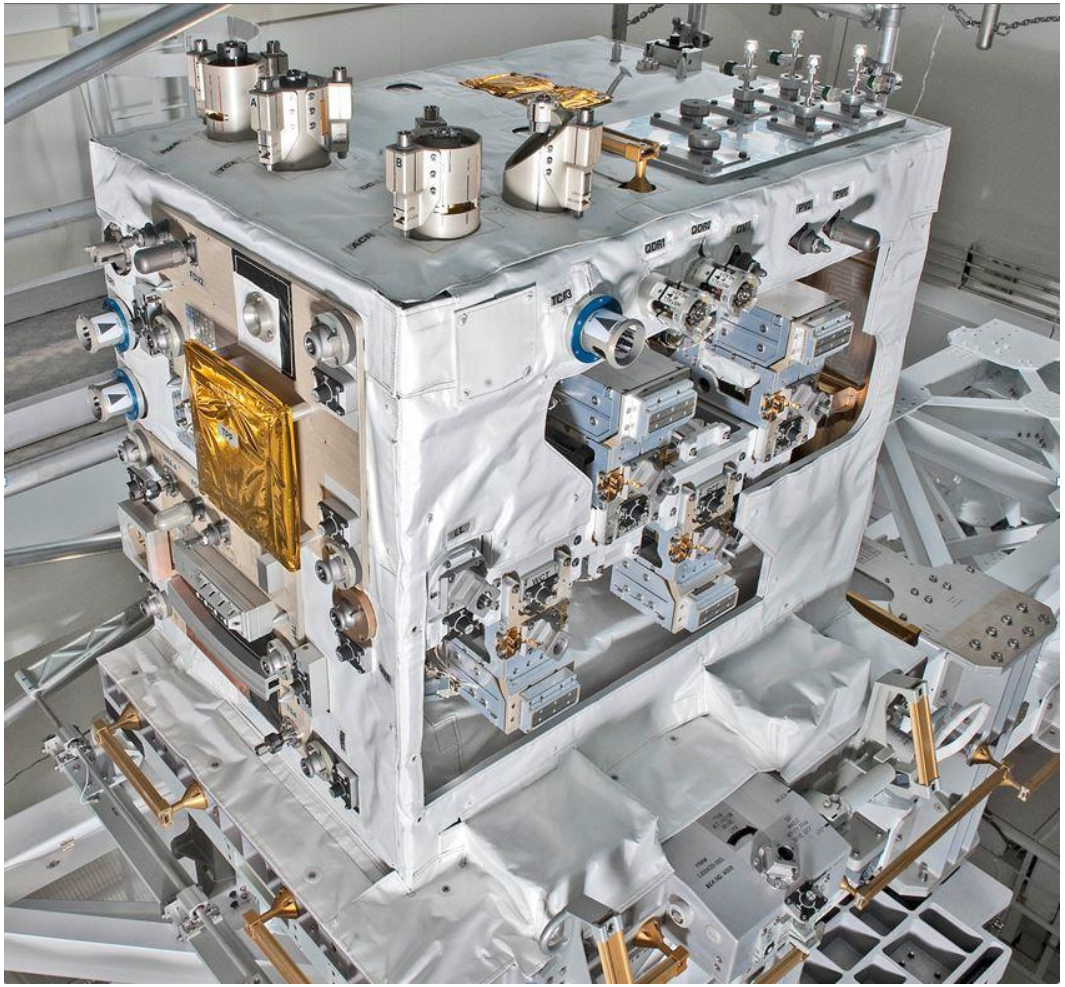


Advanced robotic tools

Propellant transfer

# Robotic Refueling Mission

**RRM was developed to demonstrate the robotic technologies needed to complete the Five "R"s and give NASA the confidence to refuel, repair and maintain satellites in both near and distant orbits.**



# Advanced Robotic Tools

## Multiple tools and adapters developed for NASA's Robotic Refueling Mission demonstration on the International Space Station.

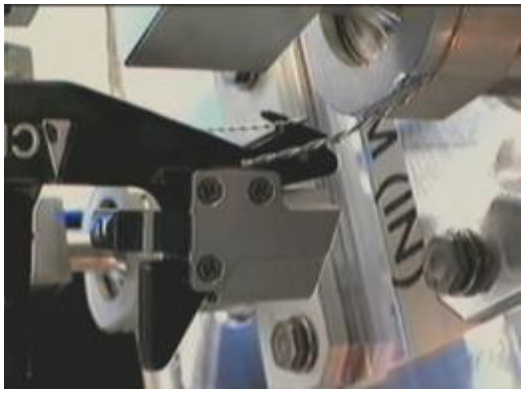
Safety Cap Tool (SCT)

EVR Nozzle Tool (ENT)

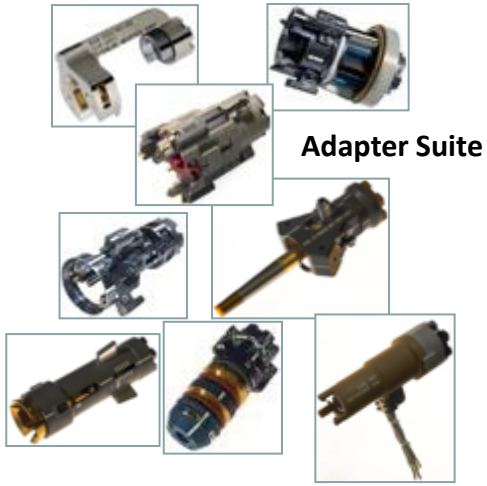
Visual Inspection Poseable Invertebrate Robot (VIPIR)

**The MFT provides an interface with several adapters.**

MLI/Wire Cutter Tool (WCT)



WCT completing cut T-Valve wire



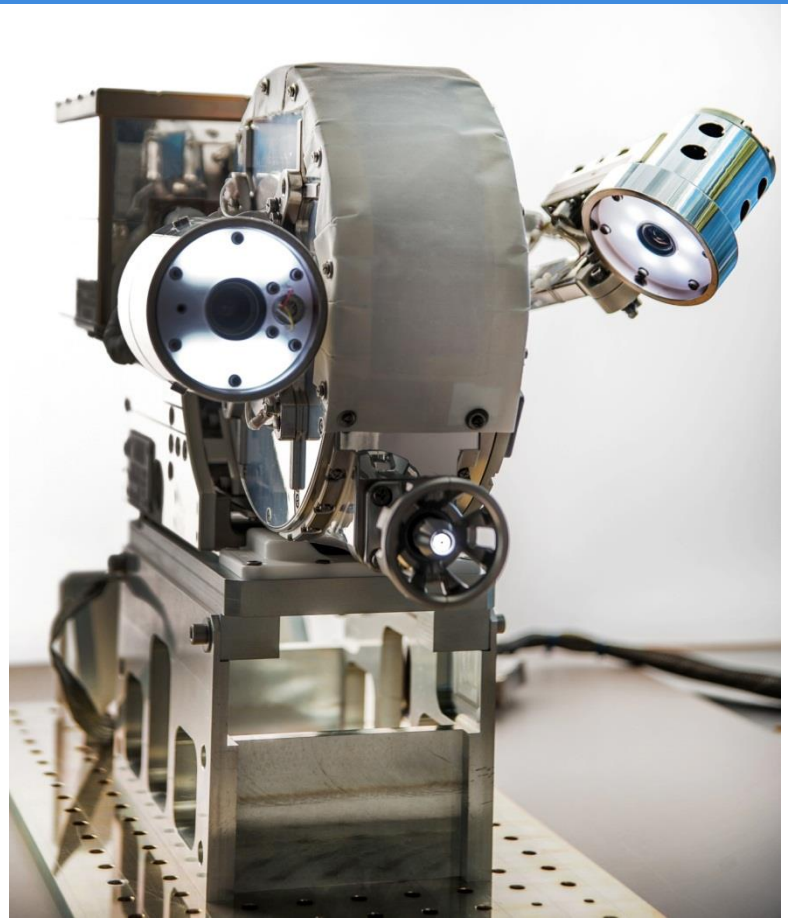
Adapter Suite

Multi-Function Tool

# VIPIR
# Visual Inspection Poseable Invertebrate Robot

**VIPIR is a robotic, teleoperated inspection tool equipped with an articulating, deployable borescope and a second motorized zoom-lens camera.**

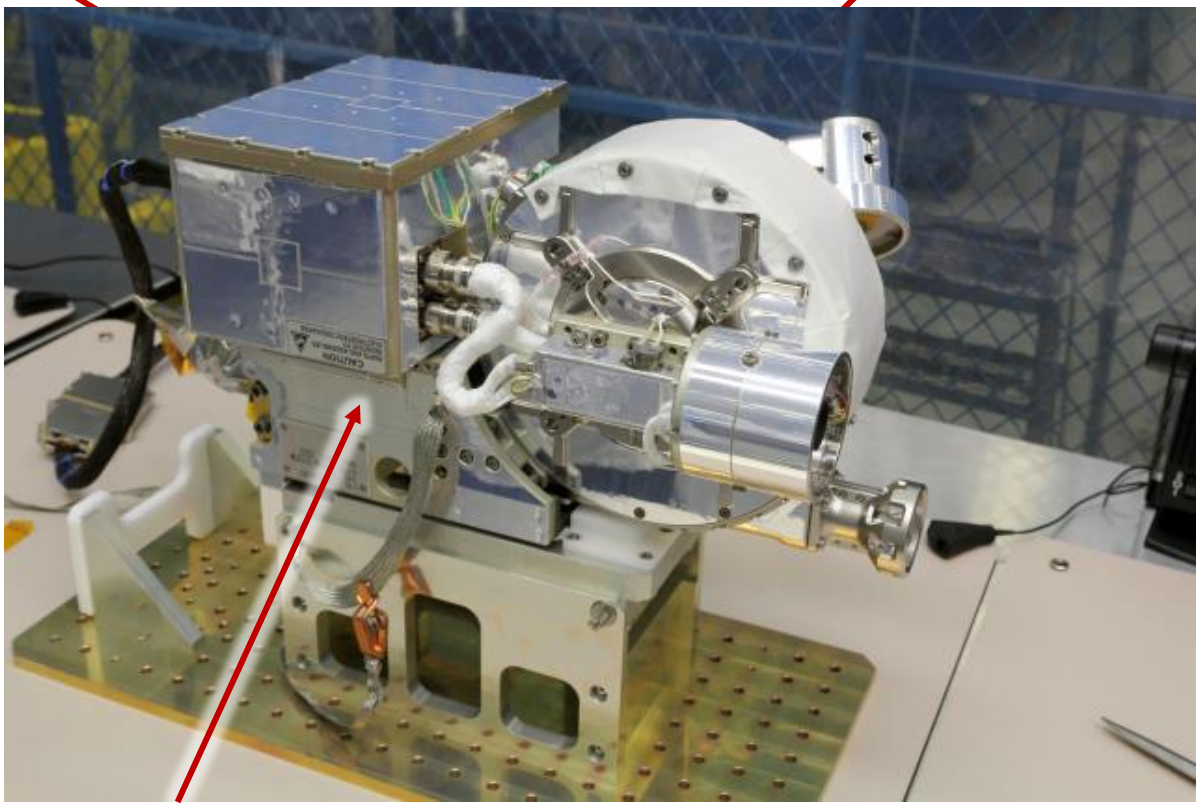
- Provides close- and midrange inspection capabilities
- Borescope
  - Nearly three feet of deployable tube
  - Final 2.5 inches rotate up to 90 degrees in four opposing directions
  - 1.2 mm color camera at tip
  - Ideal for inspection at 1-2 inches from subject
- Motorized Zoom Lens
  - 24mm optical zoom lens
  - Can resolve worksite details as tiny as 0.02 inch while tool stays 2 feet from spacecraft
- Situational camera
  - Helps control tool during operations



# VIPIR Vision System – Design Overview

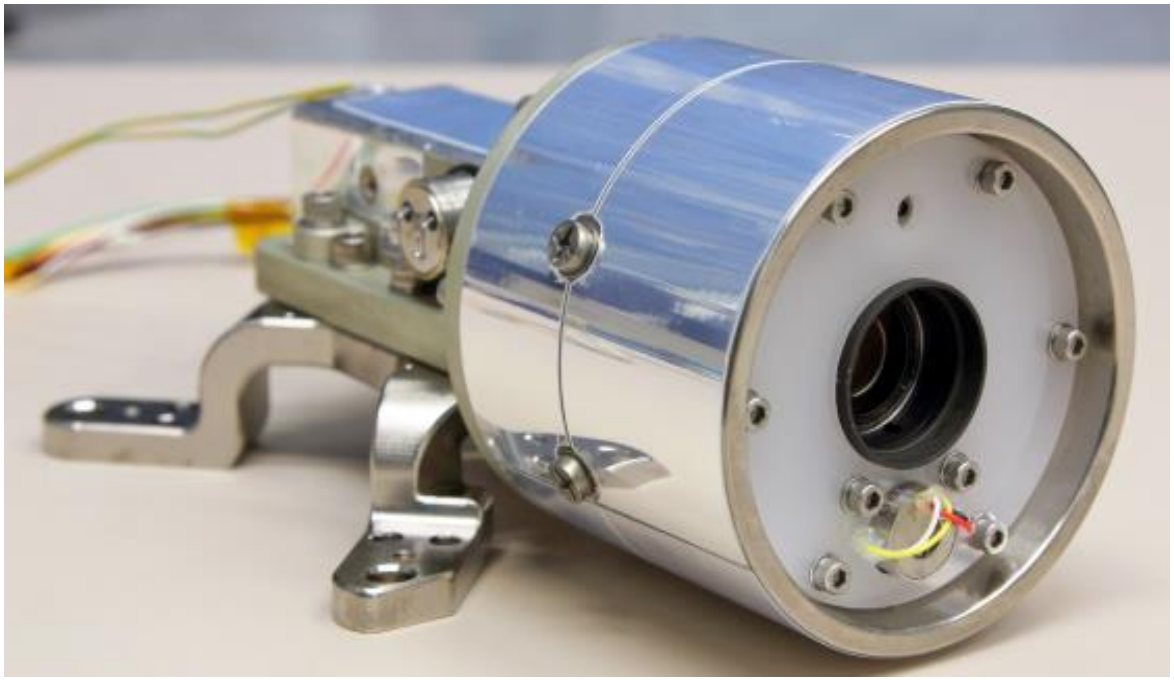
**VIPIR Electronics Box (VEB)**
Provides VIPIR Motor Controller, Power Conditioning, Camera Selector Electronics, Lighting, and Heater Electronics

**VIPIR Tool Assembly**
Electro-Mechanical Mechanism provides storage, deployment, and actuation mechanisms for the Video Borescope Assembly (VBA) “Snake Camera”



**VIPIR Support Structure (VSS)**
Provides universal RRM stowage interfaces and supporting structure for VIPIR Tool Assembly and VIPIR Vision System

# VIPIR - Motorized Zoom Lens (MZL) Camera



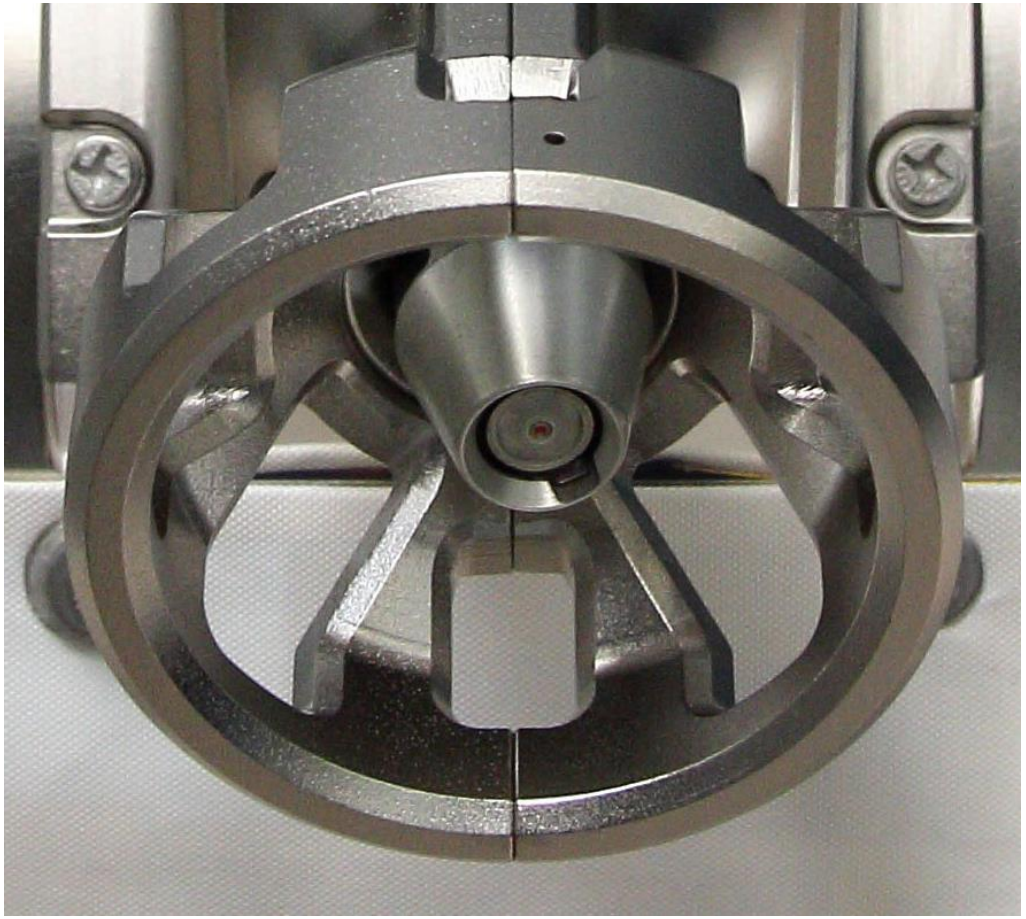
**Motorized Zoom Lens Camera**

**Mid-range Inspection Camera**

**NTSC, Color, VGA (640 x 480)**

- This camera, with miniature motorized 8-24mm optical zoom and focus capability, will be used for worksite inspection and tool positioning at 8mm focal length
- At 24mm focal length, this camera will serve as an excellent mid-range detailed inspection camera
- FOV (ideal):
  - 44˚ x 34˚ @ 8 mm
  - 15˚ x 12˚ @ 24 mm
- Pixel Pitch: 8.4 µm (H) x 9.8 µm (V)
- Focus Distance: 50 mm to infinity

# VIPIR - Video Borescope Assembly (VBA) Camera

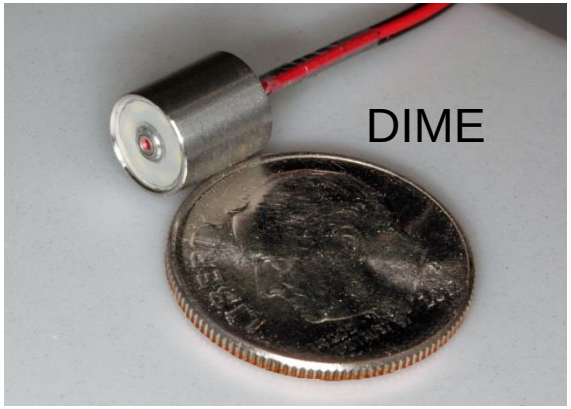


**Video Borescope Assembly (VBA)**

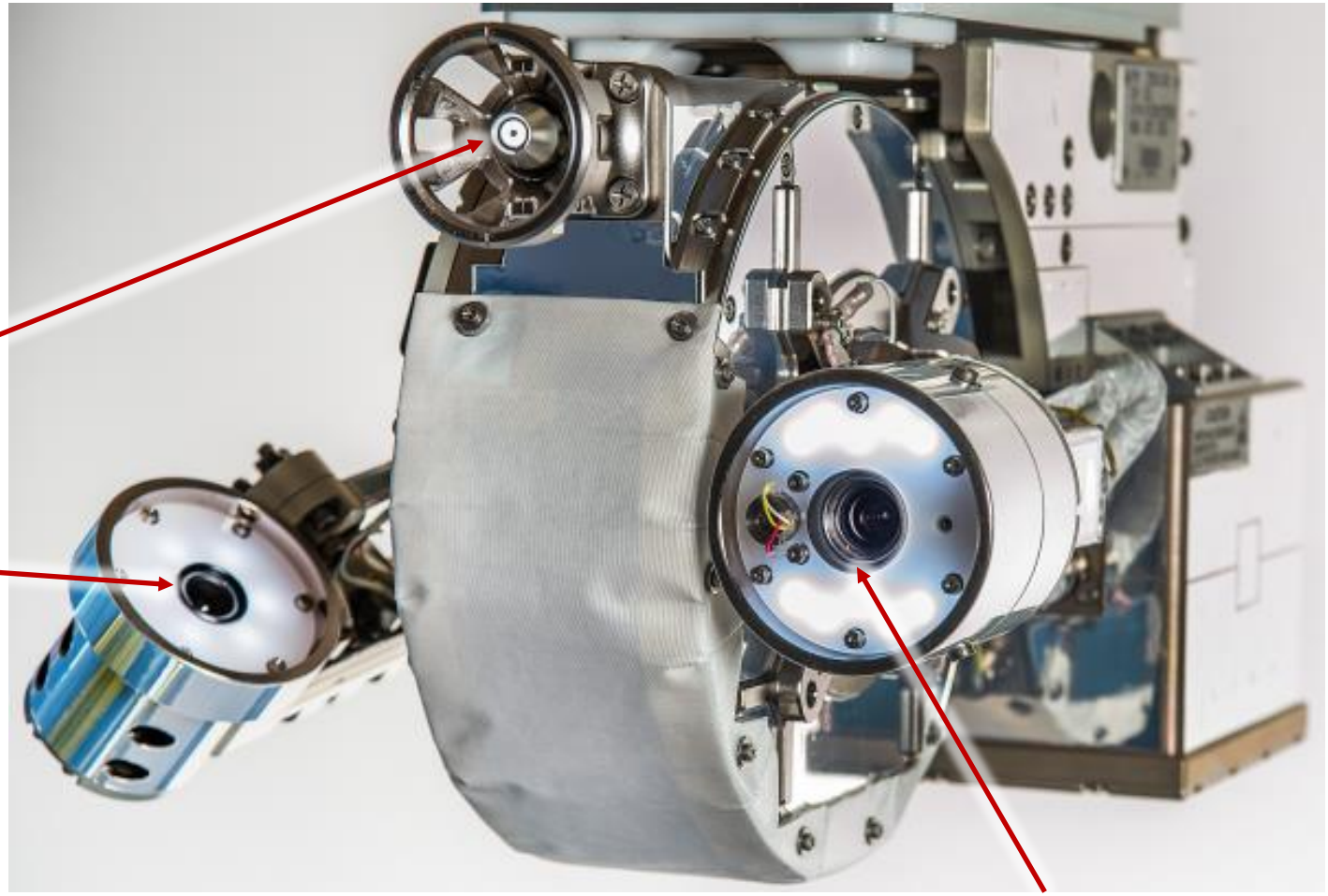
**Miniaturized Close-range Inspection Camera**

**NTSC, Color, (224 x 224)**

- This camera with lens assembly is only 1.2mm in diameter
- Designed to be deployed into an open orifice, tube, or cavity with minimum 0.90” diameter cross-section
- With integrated miniaturized lighting at the tip, the VBA provides its own lighting in very tight work spaces
- Field of View (FOV): ~100˚
- Pixel Pitch: 2.2 microns square
- Focus Distance (ideal): ~6 mm to ~50 mm



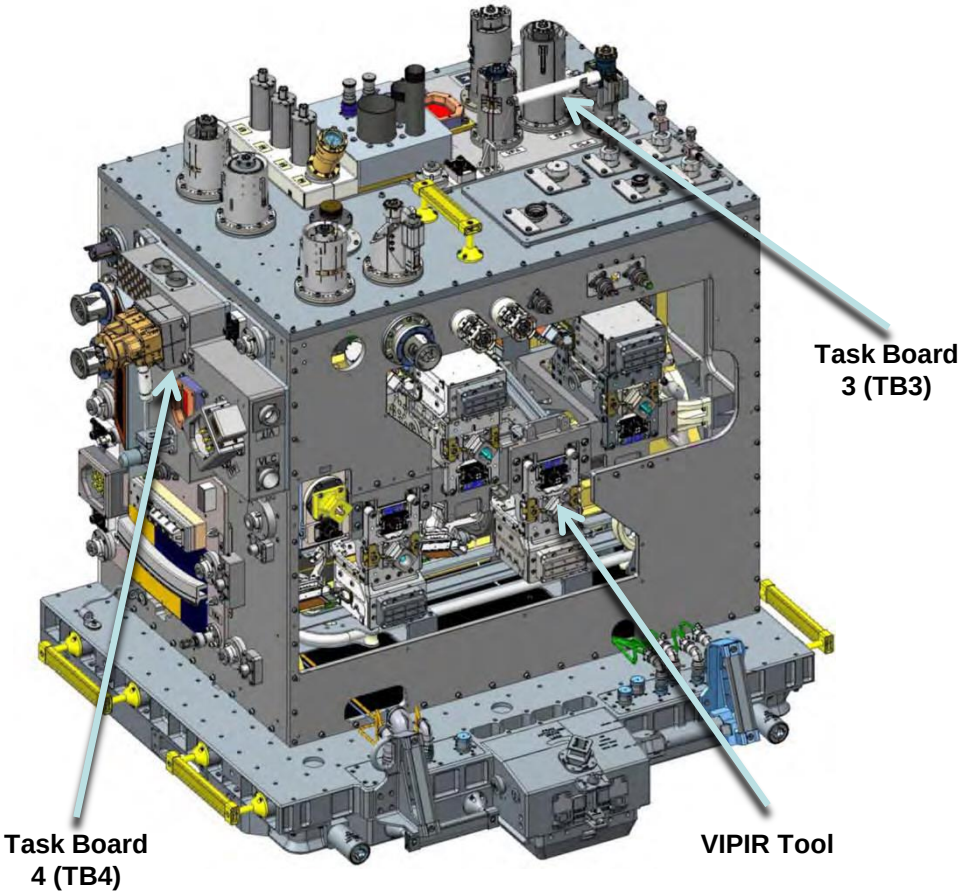
# VIPIR - Fixed Camera & VIPIR's Camera Illumination



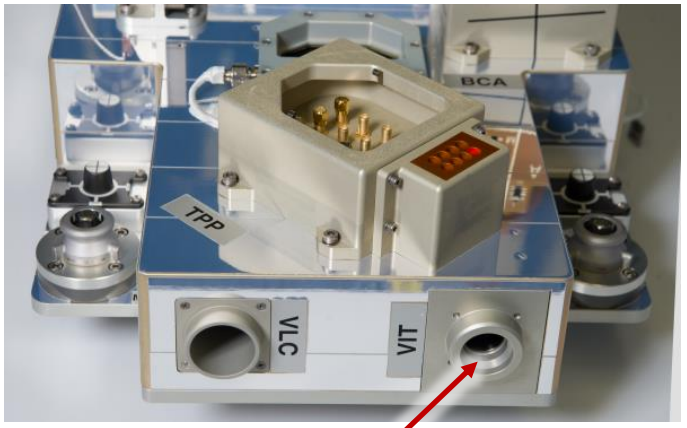

**Fixed Camera**
Primary Tool Vision Camera
**NTSC, Color, VGA (640 x 480)**
This camera, with a fixed 6mm focal length has full view of Reel Position visual indicators and will be used as the primary camera for tele-operation, tool positioning, and VBA deployment
**RRM Heritage**

# RRM Phase 2 Configuration

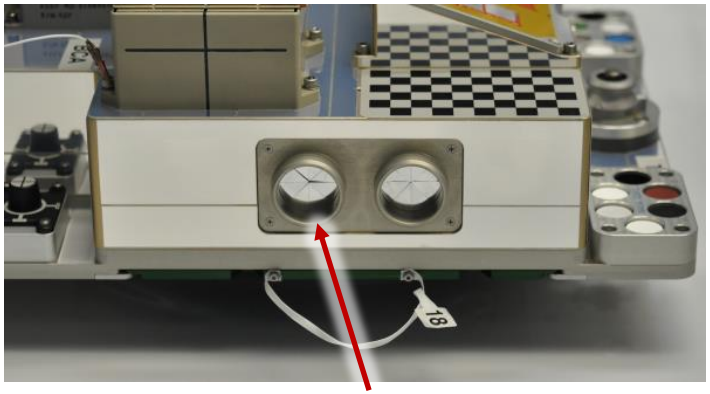
**RRM was designed to be modular to allow for augmentation with new tools and task boards to expand the technology knowledge base.**




**RRM Phase 2 Configuration**

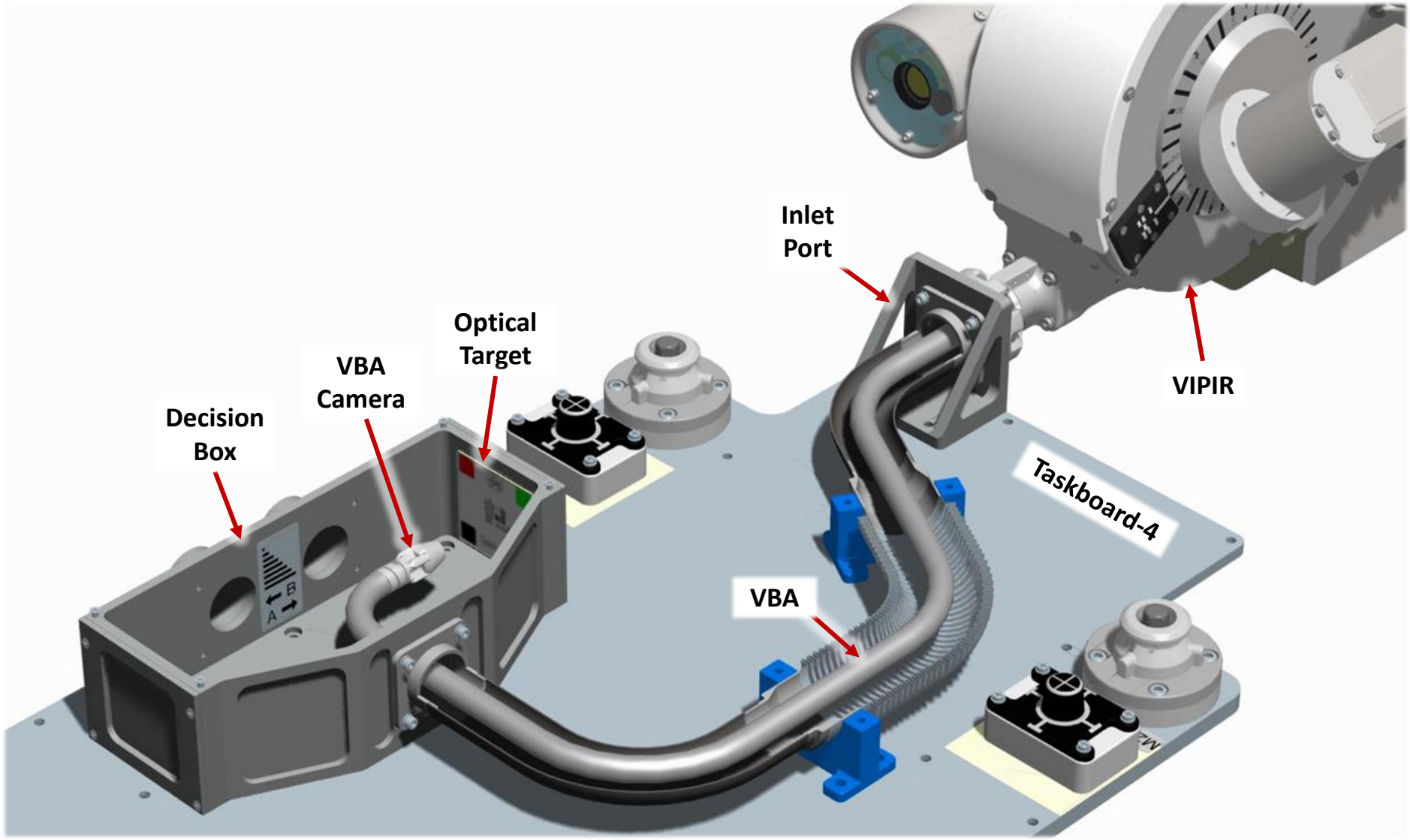



Inspection Tube Entrance Port



Inspection Tube Exit Ports

# RRM Task Board 4 - VIPIR Vision System Operation

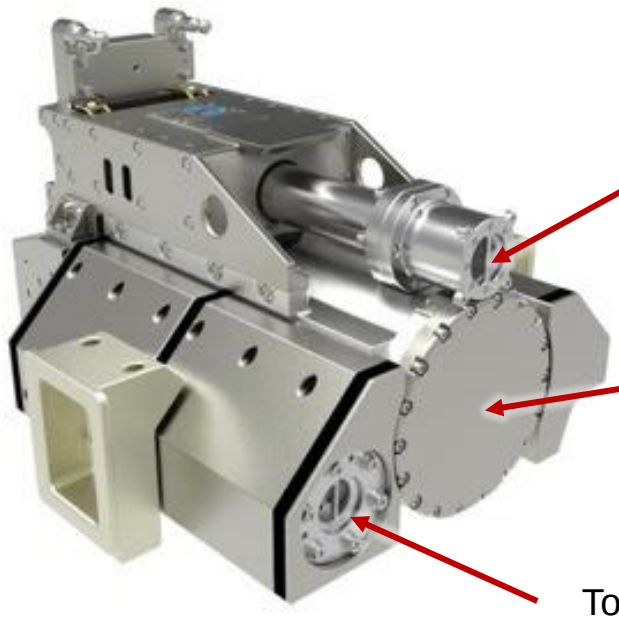


# VIPIR Video Borescope Articulation Video

# Robotic Residual Gas Analyzer Tool

**A space qualified Residual Gas Analyzer instrument that can detect minute traces of impurities in a vacuum environment**

- Mass spectrometer (RGA) and pressure gauge sense molecular flux
- Measurements at different locations and orientations provide source location
- Utilizes repackaged commercial sensors to reduce cost; sensors flight-qualified through testing
- Potential uses include environment studies and spacecraft safety, including studies of atomic oxygen and component outgassing, as well as detecting leaks in propulsion and life-support systems




*Engineering rendering*


**http://ssco.gsfc.nasa.gov**